INDIAN SUMMER AND PLIMSOLL'S MARK.

By WILLIAM GARDNER REED.

[Dated: Washington, D. C., Nov. 22, 1916.]

Prof. C. Fitzhugh Talman has directed attention to the use of the term "Indian summer" in connection with the load line marked on British ships ("Plimsoll's Mark").[1] The following is quoted from the regulations of the British Board of Trade regarding load lines:[2]

3. . . . Maximum load lines shall be as follows, and the upper edge of such lines shall respectively indicate:

For fresh water.—The maximum depth to which the vessel can be loaded in fresh water.

For Indian summer.—The maximum depth to which the vessel can be loaded for voyages during the fine season in the Indian seas, between the limits of Suez and Singapore.

For summer.—The maximum depth to which the vessel can be loaded for voyages (other than Indian summer voyages) from European and Mediterranean ports between the months of April and September, both inclusive, and as to voyages in other parts of the world (other than Indian summer voyages) the maximum depth to which the vessel can be loaded during the corresponding or recognized summer months.

For winter.—The maximum depth to which the vessel can be loaded for voyages (other than Indian summer voyages and summer voyages) from European and Mediterranean ports between the months of October and March, both inclusive, and as to voyages in other parts of the world the maximum depth to which the vessel can be loaded during the corresponding or recognized winter months.

For winter (North Atlantic).—The maximum depth to which the vessel can be loaded for voyages to, or from, the Mediterranean, or any European port, from, or to, ports in British North America, or Eastern ports in the United States, North of Cape Hatteras, between the months of October and March, both inclusive.

Such maximum load lines shall be distinguished by initial letters conspicuously marked opposite such horizontal lines as aforesaid, such initial letters being as follows:

F. W.—Fresh water.
I. S.—Indian summer.
S.—Summer.
W.—Winter.
W. N. A.—Winter, North Atlantic.

4. The upper edge of the horizontal line passing through the centre of the disk shall always indicate the maximum summer load line in salt water. The relative positions of the upper edges of the other lines to be used in connection with the disc, with the upper edge of the line passing through the center of the disc (the maximum summer load line), will be indicated in the certificate of approval. * * *

6. Steamships shall be marked on both sides with such of the horizontal lines as aforesaid as are applicable to the nature of their employment, and sailing ships shall be marked on both sides with such of the above-mentioned lines, in addition to the horizontal line passing through the center of the disc, as indicate the maximum load line for fresh water and for North Atlantic winter, but sailing ships engaged solely in the coasting trade shall only be marked, in addition to the horizontal line passing through the center of the disc, with the line indicating the maximum load line in fresh water. * * *

8. The position of the disc and the horizontal line passing through its center, as also the lines to be used in connection with the disc, are shown in the following diagrams [see plate opposite].

The form of application for marking steamers contains the statement: "The vessel is (is not) intended to be employed in the Indian Ocean." In the form of the certificate of approval are the following clauses:

(*a*) * * * the centre of such disc is placed feet inches below the deck line. * * *

(*b*) * * * the position of the lines to be used in connection with the disc shall be as follows:

* * * * *

Maximum load-line in Indian summer.—The upper edge of this line is feet inches above the horizontal line passing through the center of the disc.

* * * * *

The *freeboard for Indian summer* applies to voyages in the fine season in the Indian seas between the limits of Suez and Singapore.

The photograph (fig. 2) shows the load-line mark on the starboard of the British steamship *Dramatist*, of Liverpool, at San Pedro, Cal., October 14, 1916.

The Imperial German Insurance Office in Hamburg approved similar regulations for German ships in 1908. The load-line marking does not include a line for "Indian Summer", but the certificates contain the following statement:

Auf Grund dieser Vorschriften ist die Berechnung des Freibords obigen Dampfers vom Germanischen Lloyd ausgeführt, und sind folgende Resultate ermittelt worden:

* * * * *

Abzug vom Freibord im Indischen und Stillen Ozean während der guten Jahreszeit Meter.

* * * * *

Für Fahrten im Indischen und Stillen Ozean darf das Schiff im Sommer in Seewasser bis zu einer Ladelinie Meter über der Oberkante der Marke S [Sommer] beladen werden.[3]

The recognition of the "fine season" as the time between October and April is shown by the following quotation from a marine insurance policy on cotton from India written in London, December 31, 1868.

[The rate is to be] 50 shillings per cent. [The insurers are] to return 9/6% for sailing between 20th October and 20th April.[4]

WEATHER INSURANCE.

By WILLIAM GARDNER REED.

[Dated: U. S. Office of Farm Management, Sept. 19, 1916.]

INTRODUCTION.

The chance of unfavorable weather conditions has always been regarded as a risk the farmer must assume, and it is obvious that no farm business can be permanently successful if the profits in favorable years are not more than sufficient to offset the losses from frost, drought, and flood. When farming is regarded as a business it is clear that the cost of such losses should be carried as an annual charge against the farm business[1] because it is of exactly the same nature as fire insurance and depreciation of buildings and machinery. That a successful plan for insurance against unfavorable weather has not hitherto been devised is the result of the apparent capriciousness of the weather and also of the fact that weather conditions are generally widespread, e. g., when unusually late Spring or early Fall frosts occur they are apt to be country wide. This prevents the application of the fire insurance theory that country-wide distribution of risks will permit the payment of losses, even of great losses like the Baltimore and the San Francisco

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[1] *Talman, C. F.* Indian Summer. MONTHLY WEATHER REVIEW, January, 1915, 43: 44-45.

[2] *Great Britain, Board of Trade (Marine Department).* Statutory rules and orders, 1899, no. 8. Merchant shipping. Prevention of accidents. Load line. Regulations, dated Jan. 12, 1899, made by the Board of Trade, under the Merchant Shipping Act, 1894 (57 and 58 Vict. c. 60) [London, January, 1899].

[3] The official translation by the British Board of Trade is as follows:
"The freeboard of the above steamer has been calculated by the Germanic Lloyd on the basis of the regulations referred to, and the following results have been obtained:
* * * * *
Deduction from freeboard in the Indian and Pacific Oceans during the fine season meters.
* * * * *
For voyages in the Indian and Pacific Oceans the vessel may be loaded in sea water in Summer up to a load-line meters above the upper edge of the mark S."
See Great Britain, Board of Trade (Marine Department), Circular 1465—Official. Instructions to surveyors. Load Line—German Ships. London. March, 1909.

[4] *Plimsoll, S.* Our seamen. London, 1873. p. 23.

[1] See, for example, "Farm insurance" in U. S. Dept. Agriculture, Weekly News Letter, Oct. 4, 1916, v. 4, no. 9, p. 7.

fires, from the premiums paid in other parts of the country. Furthermore, until recently it has not been possible to analyze climatic data in such a manner as to permit the determination of the risk involved with crops at different times. For example, the manner in which frosts occur is now known, and therefore it is possible to calculate the proper annual charge to be made against a crop to cover the risk of frost damage.[2] In a like manner the frequency with which any unfavorable weather will occur in the long run may be calculated from the Weather Bureau records; but thus far the Bureau has not compiled and made available the data that may be required to form a basis for every kind of weather insurance. Much of this data is probably comprised within the original records; but a serious effort to evaluate weather insurance risks may create a demand for data not yet collected.

The distribution of risk.

It should be clearly noted than any insurance is simply a device to distribute the risk over so wide a field that the law of chance may operate as a certainty. Accidental occurrences tend to balance one another in the large and, therefore, insurance companies are not subject to the calamaties which would destroy an individual. Insurance against any happening whatever is practicable if the event has been under observation long enough to show the frequency with which it tends to occur.

Inasmuch as the only function of insurance is to balance accidental happenings against each other to eliminate their effect in individual cases, it is obvious that the total cost of properly computed premiums can not be less than the total losses which will occur. Moreover, the premiums must be large enough to carry the cost of doing business. Therefore, the cost of any insurance is somewhat greater than the losses insured against. The advantage of insurance lies in the fact that under scientific rates and properly distributed risks accidental happenings do not occur from the point of view of the company and do occur from that of the policyholder.

For this reason, corporations with widely distributed properties—e. g., railroads—customarily carry their own insurance, depositing with their insurance departments each year money sufficient to cover the annual proportion of the losses experienced in the long run. As there are no charges for advertising or soliciting and only minor charges for adjustment of losses, such corporations can obtain entirely adequate insurance at a lower cost. It is obvious, however, that this is safe only for the larger businesses operating over very wide areas.

Tornado and hail insurance.

Weather insurance of a kind is by no means unknown.[3] Of course, marine insurance has always included losses from the "perils of the sea" [4] in which the weather hazard is of prime importance, and marine insurance is in a large measure insurance against the possible results of dangerous weather. Window and plate glass insurance also involves the risk of breakage by wind and hail, as well as loss due to the entry of rain through broken windows. Hail insurance is common in parts of Europe and has received considerable attention in the central United States and Canada. As carried on here, it is the insurance of a given piece of land for a definite amount of money, usually $6 to $10 per acre west of the Mississippi River, with the possibility of somewhat larger amounts further east. The data on which these rates are based are not known to the writer and the Weather Bureau is not yet prepared to state whether the rates are excessive or inadequate.

The payments are made on the basis of the per cent of damage done to the crop; for example, if a particular acre is insured for $8 against damage by hail, after a hailstorm the number of plants in a hundred feet of row are counted and the percentage of plants damaged is determined; this is done in several parts of the field, and payment is made on the basis of the average of these counts. If the average is 50 per cent damaged, payment on the acre would be $4. Hail insurance premiums range from 8 or 10 per cent in the western part of the High Plains to 4 per cent or less with more liberal policies farther east. In Michigan a State-wide company writes hail insurance which is not definitely assigned to a particular acre, but may be applied to damage done anywhere on the farm. In the Dakotas and western Canada, however, the companies require that the particular acres to which the insurance applies be specified. Mutual hail insurance companies are said to operate successfully with State-wide risks, but not with risks confined to single counties. Such companies generally collect premiums based on the per cent of losses from hail in past years,[5] closing the business at the end of each season in the case of the mutual companies with a dividend or an assessment to make payments balance the losses. Mutual hail policies usually carry a clause permitting the assessment of an amount in addition to the premium equal to the premium paid. For example, if the rate was 6 per cent, an additional 6 per cent or any part of it might be assessed in case of losses heavier than expected or a portion returned if the amount collected for premiums was in excess of the losses and the cost of doing business. Companies insuring crops against hail generally operate independently of other companies. In addition to insurance against damage to crops, hail insurance is also written to cover damage to plate and window glass.

Tornado insurance is common in parts of the United States and Canada, specially in the Middle West. Such insurance generally includes all types of damage done to buildings by violent winds. It is usually written in connection with fire insurance, although in Canada at least one company writes a combined hail and windstorm policy. The rates vary from about half those charged for fire insurance on the same buildings in the Great Plains region to less than a quarter farther east. Tornado in-

[2] *Reed, W. G. & Tolley, H. R.* Weather as a business risk in farming. Geog. Rev., New York, July, 1916. 2:48–53. *Abstract* in MO. WEATHER REV., Washington, June, 1916, 44:354–355.

[3] See International Institute of Agriculture: Miscellaneous information relating to insurance and provident institutions in various countries. Intern. rev. of agric. econ. Rome, 1916, 67: 56–61.

[4] "*Perils of the sea* are risks peculiarly incident to navigation and particularly from wind or weather, the state of the ocean, and rocks or shores. Against dangers of this class the carrier does not insure the shipper." (Century Dictionary and Cyclopedia. New York, The Century Company, 1911, 7: 4398.)

"The words [*perils of the sea*] obviously embrace all kinds of marine casualties, such as shipwreck, foundering, stranding, &c.; as also every species of damage done to the ship or goods by the violent and immediate action of the wind and waves, as distinct from that included in the ordinary wear and tear of the voyage, or directly referable to the acts and negligence of the assured as its proximate cause." (*Arnould, J.* [Treatise] on the law of marine insurance, 8 ed., E. L. de Hart and R. I. Simey, editors. London, Stevens and Sons, 1909. p. 986.)

"The term *perils of the seas* refers only to fortuitous accidents or casualties of the seas. It does not include the ordinary action of the winds and waves." (Rule 7 "for the construction of ... [Lloyd's S. G.] policy ... under ... ['The Marine Insurance Act, 1906.']," *ibid.* p. 1596.)

[5] As an example of the rates and classes of risks in actual practice, the following "Rates for hail insurance on growing grain crops [in eastern Canada]" may be quoted:

"Rates per $100 of insurance for $2, $3, $4, $5, $6, $7, $8, $9, or $10 per acre: First class, $3; second class, $4; third class, $5; fourth class, $6.

"The class of risk is determined as follows:

"*First class.*—Where hail has not injured or destroyed the crops growing on any part of the land to be described in the application for insurance in the 10 growing seasons last past.

"*Second class.*—Where hail has injured or destroyed the crops growing on any part of the land * * * only once in 10 growing seasons last past.

"*Third class.*—Where hail has injured or destroyed the crops growing on any part of the land * * * only twice in the 10 growing seasons last past.

"*Fourth class.*—Where hail has injured or destroyed the crops growing on any part of the land * * * only three times in the 10 growing seasons last past."

These rates are cited as examples; the Weather Bureau does not indorse them.

surance has been carried on successfully by mutual companies having State-wide risks, but has not been practicable for companies having only county-wide risks, although fire insurance companies are in successful operation within the limits of many single counties.

Practically all fire insurance policies recognize lightning as a probable cause of fire. All these types of weather insurance, however, are based on the fact that these phenomena are relatively so rare that they may be regarded as accidental at any particular locality, although it is recognized that they are more frequent in some places than in others and the rates vary as has been noted to allow for this difference in frequency. But such variation in rates rests on a rather indefinite mathematical basis. The following statement by the eminent French meteorologist Angot [6] is of interest in this connection as showing present conditions in much more densely populated France:

> It will be very important to have numerous exact observations on the falls of hail in France. At the present time the available stations do not enable us to draw charts showing the distribution of hail, that are sufficiently detailed to be valuable. I pointed out this insufficiency more than 10 years ago in studying the storms of 1903, and I have shown that in order to make a complete study of the distribution of hail over a small Department like the Rhone, it would be necessary to have from 280 to 300 stations uniformly distributed. A large Department like the Gironde or the Dordogne would need about 1,000 stations. These numbers suffice to show the difficulties of the problem.

Only the very infrequent occurrence of the phenomenon makes such insurance possible.[7]

The following statement also may be worth considering:

> Anyone who examines the results obtained both by the large mutual societies and by the companies with fixed premiums will be struck by the fluctuations to which both groups are subject.
>
> In 1894, a very favorable year, the net profits rose for both classes to 3,000,000 francs, and the reserve funds to not less than 7,000,000. But in 1897, a bad year, the losses were 1,630,000 francs and the total amount of the reserve funds was about 3,500,000 francs. There was, therefore, in the interval of three years, a difference of nearly 8,000,000 francs.
>
> This comparison of figures is alone sufficient to show the difficulties encountered by hail insurance societies in establishing scientific combinations and reasonable tariffs. It is certain that these questions have not yet been definitely decided, and they will remain a subject for technical consideration until a scientific solution has been arrived at, as only by the investigation of the laws of storms and cyclones can a means of efficacious protection be found against them.
>
> In fact there are no hail insurance tariffs, but some cantons or communes have a splendid system of payments according to their situation, to the exposure of the land, and to the frequency of hailstorms.
>
> The rates are fixed either in accordance with the nature of the insured crops and the frequency of losses in a given period or by contract, according to the amount assured.
>
> (International Institute of Agriculture, monthly bulletin of economic and social intelligence, No. 9, October, 1913.33: 41-42.)

"*Lloyd's.*"

Another kind of weather insurance is that written by the London "Lloyd's." This, however, is much in the nature of race-track bookmaking.[8] The chance of any event whatever happening or not happening can be insured at Lloyd's by anyone who is willing to pay the premium; but because of the fact that the only real security of Lloyd's is its immense resources and the wide distribution of its risks over the whole range of insurance and over the whole world as a field [9] the premiums are much higher than they would be if the chances of occurrence were accurately computed.[10] It is customary to insure outdoor events against the occurrence of rain and the premiums are fixed largely on a general knowledge of the frequency of rainy days.

Frequency distributions.

The fundamental mathematical basis of all scientific insurance is the frequency distribution. A study of sufficiently extensive data makes it possible to predict how the events will occur in the long run and the wide distribution of risks makes accidental happenings offset one another. The basis of life insurance is the life table of the actuary, and similar tables are available for fire insurance.

The characteristic distributions of meteorological phenomena have not been studied until recently, because any individual record is too short to furnish the required number of data. Modern statistical methods, however, afford a means of handling these records in the mass and of obtaining results within usable limits of error.[11]

The frequency distributions of Spring and Fall frosts in the United States have been studied,[12] and the chance of killing frost after any date in Spring or before any date in Fall can be determined so accurately that the lack of agreement between calculated and actual occurrences at 569 stations with records varying from 59 to 15 years in length is only about 50 cases in 27,000, or less than 0.2 per cent.

Although the characteristic frequency distribution toward which meteorological phenomena tend is not necessarily the same for all phenomena, the records now available permit the arrangement of these data so that the frequencies can be determined. In the United States the compilation of the data and the study of frequencies has been comprehensive only for frost; preliminary studies of temperature and rainfall data indicate that their respective frequencies also may be determined to a useful degree of accuracy.

The Law of Chance.

All insurance is based on the well-known fact that when a sufficiently large number of happenings are considered there are no accidental occurrences. Any grouping of special cases in one place or at one time will be balanced by a complementary grouping in another place or at another time. The grouping toward which the distribution of the phenomenon tends is a smooth curve when the number of cases is infinite. Studies by various mathematical statisticians have shown that even with as few as 500 occurrences the accidental irregularities tend to balance one another and hence may usually be neg-

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[6] MONTHLY WEATHER REVIEW, March, 1914, 42: 167.

[7] An insurance company in Canada, is licensed to write "insurance against injury to property caused by cyclones, tornadoes, windstorms, frost or hail, except with respect to propery in transit on water," but its business consists in large part of hail insurance. (See Canada, Superintendent of insurance, Report for 1915. Ottawa, 1916, vol. 1 (Insurance companies other than life), pp. xxxi, clxix, and clxxvi.)

This company has apparently written only tornado (windstorm) and hail (including plate and window glass damage) insurance; its circulars state that rates on frost and forms of policies for insurance against frost damage will be furnished shortly.

[8] This statement is not to be interpreted as derogatory to Lloyd's business, which is entirely legitimate; the rates are determined by competition and in the light of all the information collected by an intelligence system superior to any the world has ever known.

[9] See Martin, F.: "Parliamentary inquiry into marine insurance" *in* History of Lloyd's and of marine insurance in Great Britain, pp. 229-252. Macmillan, London, 1876.

[10] However, the practice at Lloyd's of underwriting risks in parts ("lines") until the whole is covered and the competition resulting from the active trading tends to keep the premiums as low as possible. But the main point stands—this type of insurance at Lloyd's rests on no secure mathematical basis except the compensation of large numbers, immense resources, and widely distributed risks.

[11] *British Meteorological Office.* The computer's handbook (M. O. 223-Official), Section 5: Computations related to the theory of probabilities.

1. *Corless, R.* Errors of observations and variations due to accidental causes with an application to errors of means and normals.

2. *Dines, W. H.* The practical application of statistical methods to meteorology. London. 1915.

Franklin, W. S. Statistical physics. Science, August 4, 1916 (N. S.) 44: 158-162.

[12] *Reed, W., G. & Tolley, H. R.* Weather as a business risk in farming. Geogr. rev., New York, July, 1916, 2: 48-53. Abstract in MO. WEATHER REV., June, 1916, 44: 354-355.

lected. This fact is fundamental to all determinations of insurance rates, because no insurance company is carrying risks which even approach infinity. If more than a very moderate number of well-distributed risks were necessary to eliminate the accidental, insurance would be far less useful than it is. In weather insurance it is essential only that the risks be so arranged that the rare conditions, even if country wide, will not operate to disturb the financial equilibrium of the company. A study of 569 long records at Weather Bureau stations has shown that there were no unexpected frosts at 414 of the 569 stations (73 per cent) when frost was predicted on the basis of the 10 per cent hazard; and not more than one such frost during the entire record at 94 per cent of the stations.[13] This is not limited to frost conditions but is found to be general in all studies dealing with chance. When once the form of the frequency curve has been adequately ascertained, a number of cases, small when considered from a statistical standpoint, although perhaps large humanly speaking, is sufficient to insure that accidental happenings will so far balance one another that insurance is as safe as if the number of risks were infinite.

Weather and crops.

The control of crops by the weather is obvious and well known. However, weather alone is not responsible for good or poor yields; there are other factors among which the ability and industry of the farmer are of great importance. Weather may be looked upon as a fundamental control, and the necessity of having the right temperature and the right precipitation at the critical times has been clearly shown.[14] Favorable weather even with good soil conditions, excellent cultural methods, and absence of insect and other pests does not necessarily mean high prices, although the yields may be large.[15] Returns from agricultural production are to a very large extent dependent upon the relation of supply to demand. Therefore, when high yields are general prices tend to be low.

But good yields can not be obtained without favorable weather unless some method of preventing damage by the unfavorable weather is adopted (e. g., frost protection). Therefore, a prime requisite of good returns from agriculture is favorable weather; because the fact that prices are high is of little importance to a farmer without a crop to sell. In general favorable weather conditions mean good yields, and prosperity generally follows favorable weather.[16]

The farm business and the weather hazard.

Farm management investigations consider farming from the point of view of the farm as a business unit. When the farm is the unit, the question of high or low yields of particular crops is far from the only thing to be taken into account. The selection of the crops best suited to the region from both climatic and economic points of view has to be considered. This includes the proper arrangement of rotations, the size of the farm, and many other items. It also includes the determination of the proper charges against the farm for interest on the investment in land, buildings, and equipment, depreciation on buildings and machinery, insurance, and taxes; that is, the whole range of charges which go to make up the cost of doing business and which must be added to the product as "burden" if the business is to be successful. Fire insurance has always been regarded as a necessary charge against the farm. Insurance against unfavorable weather has, however, not been carried as such although losses from unfavorable weather are common. This does not mean that the cost of unfavorable weather has not been included in the "burden" assessed against the crops. Heretofore this has been carried mainly in two ways, the attempt to carry the hazard by a large enough profit and loss account or the depreciation of land value to a point where the interest charge will be low enough to permit the capital account to carry the hazard. Needless to say, neither method can be regarded as correct, because the cost of carrying the risk is not accurately determined and the operation of the many other factors prevents the unimpeded operation of the weather hazard.[17]

Therefore, although the farm business can not escape the burden of the weather hazard, the charge for this risk is now unevenly borne. The adequate determination of the chance of unfavorable weather and the proper distribution of the risk by insurance would make it possible to charge the farm business with the correct insurance premium and to substitute a definite charge for an indefinite and expensive hazard.

Weather Insurance Premiums.

Aside from accidental occurrences, the risk of which must be distributed by the operation of the law of large numbers, it is entirely practicable for the individual farmer to carry his own insurance. For example, he may decide to plant his crop at such a time that the chance of safety from spring frost is 9 in 10, that is at a date after which the calculations show the occurrence of killing frost in only 10 years in 100, or 1 in 10 in the long run. If he could be reasonably sure that any given 10 years would follow the average conditions, he would be justified in laying aside one-tenth of the sum he will probably lose in the one unfavorable year. The date on which the chance of killing frost falls to 10 per cent has been determined for over 500 places in the United States. These places are so distributed that a fairly close approximation of the date for almost any place in the country can be determined. A farmer whose loss from an unexpected spring frost would be, say, $1,000 in any one year might plant his crop at the date of 10 per cent risk and put $100 in a savings bank each year. The interest resulting from this investment may be disregarded for the sake of simplicity. At some time during the 10-year period he will lose a crop by spring frost and will then need his $1,000. If this occurs in the tenth year, he will have his money to draw from the bank. If it occurs before the tenth year he will have part of the money available, but he will have to borrow the rest, to be repaid at the rate of $100 a year. But at such a time there will be other losses in the neighborhood and money will be hard to obtain. In addition to this even a casual study of the climatic data shows that no single 10-year period is likely to fulfill the average conditions, so that while the farm business might well afford to carry the risk on the basis of 10 such losses in a century, these losses will almost cer-

[13] *Spillman, W. J., Tolley, H. R., & Reed, W. G.* The average interval curve and its application to meteorological phenomena. Mo. WEATHER REV., April, 1916, **44**: 199.

[14] *Smith, J. Warren.* The effect of weather on the yield of corn. Mo. WEATHER REV., February, 1914, **42**: 78-92.
The effect of weather upon the yield of potatoes. Mo. WEATHER REV., May, 1915, **43**: 222-236.

[15] Sir John Lawes' old maxim "High farming is no cure for low prices," is still true. See *Hall, A. D.* Agriculture after the war. London, John Murray, 1916. p. 105.

[16] *Clayton, H. H.* The influence of rainfall on commerce and politics. Pop. sci. mo., New York, December, 1901, **60**: 153-165.

[17] *See for example* E. J. Russell *in* Nature, London, Aug. 3, 1916, **97**: 460.

tainly be so grouped that an individual farmer could not do so without bankruptcy.

The climatic data show clearly that the chance of frost may be determined with considerable accuracy. An insurance company operating over a field wide enough to eliminate the possibility of bankruptcy on account of simultaneous losses in a whole country or large section of a country would be able to arrange such insurance even if the farmer discountinued his policy when a loss was paid. A company whose operations were confined even to the United States would probably be under the necessity of writing its policies in the form of long time contracts under which premiums would be paid each year and the face value paid when the losses occurred. The premiums would continue through the period of the contract without regard to payments on account of frost occurrence. The period covered by the policy should be equal to that of the average interval between losses—10 years for losses under a 10-per cent risk, 20 years for losses under a 5-per cent risk, etc.

In order to test the practicability of such insurance the frost records of Kansas and Ohio have been analyzed. The numerical data and figures presented are not final values on which insurance may be based; but they indicate the kind of data and approximate values to be derived from existing observational records. It has been assumed that each cooperative station in these States, reporting to the Weather Bureau, was insured for $1,000 in 1906 under a 10-year contract. The premium was assumed at $100 per year and the value of the policy ($1,000) was to be paid whenever a killing frost in Spring occurred on or after a date stated in the policy; this date is 4 days (about the average probable error) later than the date of 10 per cent chance of killing frost.[18] The net results of this insurance appear from Table 1.

The gross profit from the insurance is mainly the result of the 4-day margin of safety. This, together with the interest on the premiums, is probably sufficient to cover the cost of doing business and to provide a small reserve to increase the security. If the reserve becomes too large or too small, the dates should be recalculated with the aid of the constantly accumulating new climatic data, and if it appears to be the result of a peculiar combination of years, the reserve should be held against the future. If, however, it appears that the condition is the result of a margin of safety too large or too small, the margin should be changed to fit the actual conditions.

TABLE 1.—*Net results of the imaginary insurance project computed as an example for Kansas and Ohio, 1906.*

	Premium payments.	Losses.	Reserve and operating account.
Capital			$100,000
1906.			
Ohio	$9,500	$2,000	
Kansas	5,400	11,000	1,700
Balance			98,300
1907.			
Ohio	5,900	22,000	
Kansas	5,400	39,000	49,700
Balance			48,600

[18] *Spillman, W. J., Tolley, H. R., & Reed, W. G.* The average-interval curve and its application to meteorological phenomena. MONTHLY WEATHER REVIEW, April, 1916, 44: 197-200.
Reed, W. G. The probable growing season. MONTHLY WEATHER REVIEW, September 1916, 44: 509-512.

TABLE 1.—*Net results of the imaginary insurance project computed as an example for Kansas and Ohio, 1906*—Continued.

	Premium payments.	Losses.	Reserve and operating account.
1908.			
Ohio	5,900	None.	
Kansas	$5,400	$1,000	$10,300
Balance			58,900
1909.			
Ohio	5,900	None.	
Kansas	5,400	None.	11,300
Balance			70,200
1910.			
Ohio	5,900	1,000	
Kansas	5,400	None.	10,300
Balance			80,500
1911.			
Ohio	5,900	None.	
Kansas	5,400	None.	11,300
Balance			91,800
1912.			
Ohio	5,900	7,000	
Kansas	5,400	1,000	3,300
Balance			95,100
1913.			
Ohio	5,900	None.	
Kansas	5,400	8,000	3,300
Balance			98,400
1914.			
Ohio	5,900	None.	
Kansas	5,400	3,000	8,300
Balance			106,700
1915			
Ohio	5,900	2,000	
Kansas	5,400	3,000	6,300
Balance			113,000

When compared with fire insurance the premiums necessary are large. This is because of the difference in the character of the risk. The chance of the loss of any given building by fire is 1 in 300 or 400, while the chance of killing frost after the date named in the policy is 1 in 10.

Practicable insurance against frost is not limited to a 10 per cent risk. Table 2 indicates in a general way the relative range of premiums payable for a policy of $1,000 for a place where the average date of last killing frost in Spring is April 15 and the standard deviation of spring frost dates is 11.7 days.

TABLE 2.—*Type of rate schedule. Fixed payment for loss.*

[Rates per $1,000 on Spring frost when average date is Apr. 15 and standard deviation of last killing frost is 11.7 days.]

Face of policy—Payable if killing frost occurs on or after—	Relative annual premium per $1,000
Apr. 20	490
25	334
30	200
May 5	100
10	44
15	17
20	5
25	1

Adjustments for local topography should operate to increase premium for valley bottoms, etc. and to decrease premiums for hillsides.

TABLE 3.—*Type of payment schedule. Fixed premium.*

[Amounts payable for $10 annual premium, when average date Fall frost is Oct. 15 and standard deviation of first killing frost is 12 days.]

When killing frost occurs before—	The relative payment is—
Sept. 15	575
20	225
25	100
30	50
Oct. 5	30
10	20

Adjustments should be made for local topography. Hillsides should be given higher payments, valley bottoms lower payments than those shown.

Table 3 is of similar character for insurance computed in another manner. Here the premium is fixed and the amounts payable if frost occurs before specified dates in the Fall is stated. Each method can be employed for either Spring or Fall frost. Although the application to Spring frost, of the method indicated by Table 3, requires the adoption of a business procedure such as the payment of no losses until after July and no policies written after some date in the early Spring; for example, the average date of last killing frost.

These illustrations show only two of the many possible methods of frost insurance. The frequency distribution of the critical frost dates has been studied in enough detail to enable determinations of the chance of frost at any time to be made for nearly all the agricultural regions of the United States.

Although other phenomena do not show the same frequency distributions as critical frost dates, the distributions for many of these phenomena have been partially investigated and the mathematical studies already completed indicate that the chance of any weather condition at all can be determined with more or less accuracy. Therefore practicable insurance against any unfavorable weather depends solely upon the determination of the hazard and a sufficient number of properly distributed risks.

It may prove possible after weather insurance companies have become well established to write insurance on the basis of crop damage not to exceed the face of the policy. It is not yet practicable to insure a farmer to have a good crop because of the fact that the value of the crop depends on so many causes other than the weather, and insurance of the crop against weather damage rather than insurance against the fact of unfavorable weather will put the better farmers at a disadvantage unless a satisfactory adjustment for the personal and moral elements can be determined.

CONCLUSION.

The farmer has always recognized that the chance of loss must be taken into account and that the returns in favorable years must carry the losses from unfavorable years. The farm business must be operated with a large enough profit and loss margin to cover these losses. The farmer has attempted to cover the risk of loss by diversification and by the selection of planting dates late enough for the chance of frost to be small. The date in each region has been determined by custom and these dates are those determined by the farmers of the region who have not suffered from loss by frost often enough to become bankrupt. These dates of planting rest on an empirical basis as a result of experience. A statistical determination of the risk involved at various times will show how far custom is the result of actual conditions in the region and how far other factors—e. g., tradition—have influenced the dates.

When the risk of loss from unfavorable weather is accurately determined and the crop of each year carries its proper portion of this risk, especially if the risks are widely distributed by insurance, bankruptcy as a result of unseasonable weather is transferred from the class of calamities to that of avoidable losses. In all cases when the chance of loss can be computed in a very large number of cases insurance is the proper method of eliminating the chance of accidental grouping of unfavorable occurrences from bearing too heavily upon the individual. Therefore, the distribution of the risk of crop damage from any condition for which the risk can be computed is a legitimate field for insurance. It is clear that weather hazard can be so determined in many instances and that insurance against the occurrence of killing frost or any unfavorable weather condition may be arranged not as a gambling operation between the farmer and the insurance company but on a sound business basis.

When such insurance has become well established it will be applicable in a much wider field than the simple distribution of the risk of the individual farmer. For example, the insurance rate quoted on a farm will give the purchaser information which will assist him in a determination of the just value; the country banker and storekeeper will be able to insure themselves so that the depression resulting from poor crops will not bear too heavily at any one time; and weather insurance in connection with farm loans may well become as general as fire insurance with loans on buildings and goods or life insurance with personal notes. The fact that the weather hazard is coming into the same class as the fire hazard in that it may be offset by a fixed charge makes possible another step in the series of farm management studies which is developing the business side of farming from a phrase to a reality.

WHAT IS A "GEOCOL"?

In the REVIEW for July, 1916, page 393, was reprinted an article on the rainfall of New South Wales, wherein was employed the geographical term "geocol" when describing the influence of Australia's topography on the rainfall of New South Wales. "Geocol" is not defined in the latest of our large dictionaries, and as the feature is an interesting one the text of the original definition is quoted.[1]

> If the stereogram (or relief map) of New South Wales be examined, it is seen * * * that the main divide is constituted of three well-defined land masses separated by *cols on a gigantic scale*. For these the term *Geocol* is suggested (analogous to Geosyncline) to differentiate these important positive land forms from the ordinary col between two hills.

Concerning the etymology of this word, Taylor has elsewhere[2] stated:

> "Geocol" is admittedly a hybrid word of the same form as peneplain. The prefix geo- is added in the same sense as in geosyncline and geanticline.

[1] *Taylor, Griffith.* A correlation of contour and climate. Proc., Linnean soc. New South Wales, Sydney, 1906, 31:517.

[2] *Taylor, Griffith.* Physiography of eastern Australia. [Melbourne, 1911.] p. 13, footnote. (Australia. Bur. Met'y., Bull. no. 8. 4°.)